Mechanical Power Engineering Dept.
3rd Year Mech. Power Eng.
Refrigeration and Air conditioning

Tanta University
Faculty of Engineering

SHEET (5)
Duct and pipe sizing

1. For the duct system shown, it is required to compute the total pressure loss where the velocity of the air is 10 m/s and size the duct.

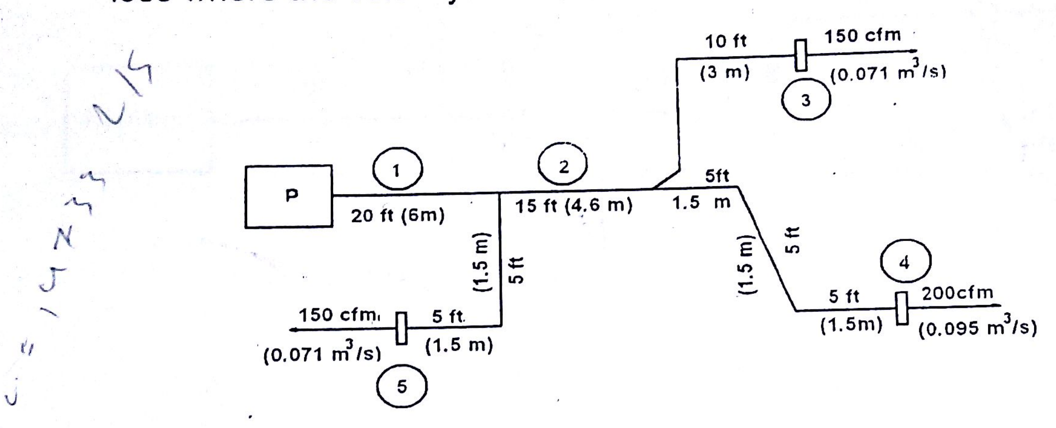


Fig-1 Problem no.1

2. Consider the duct layout shown in Fig-2. The system is supplied air by a rooftop unit that has internal pressure losses of 500 Pa. the ducts are to be rectangular cross section and the maximum velocity in the main run is 5 m/s. Size the supply ducts to fit his system using the equal friction method. Show the location of any required dampers.

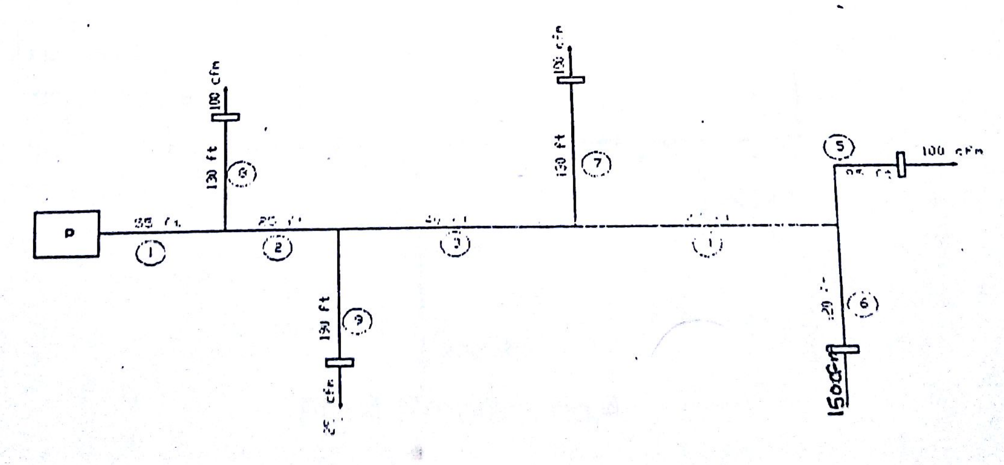


Fig-2 Problem no.2

3. The duct system shown in Fig-3 is one branch of a complete air distribution system. The system is a perimeter type located below the floor. Size the duct system using round steel duct..
(assume that maximum velocity in main duct is 7.5 m/s)

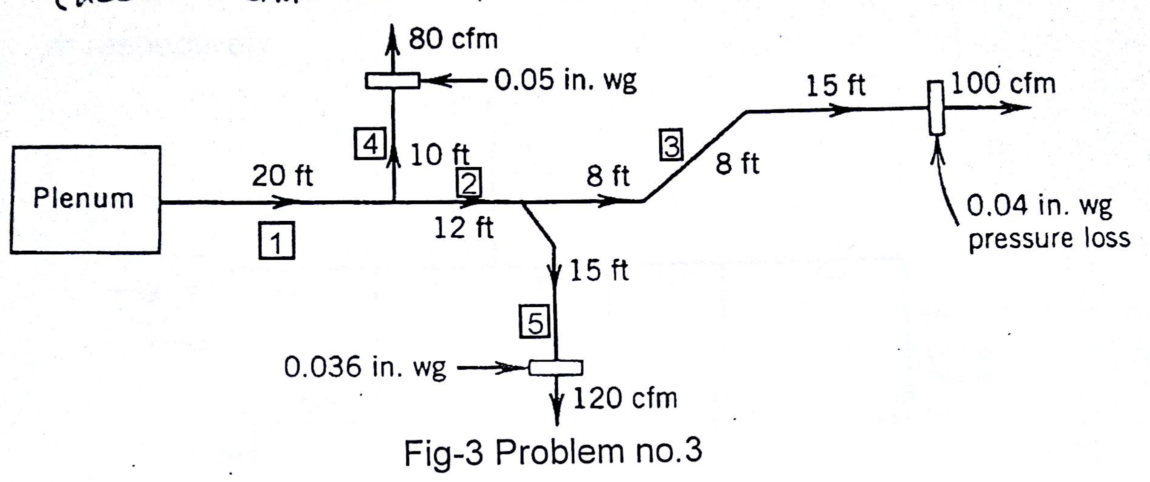


Fig-3 Problem no.3

4. Consider the duct system shown in Fig-4. The maximum velocity in the main run is 1200 fpm, Size the ducts using the equal friction method and compute the total pressure loss. Assume that, the equivalent length for each fitting losses, is 0.9 m

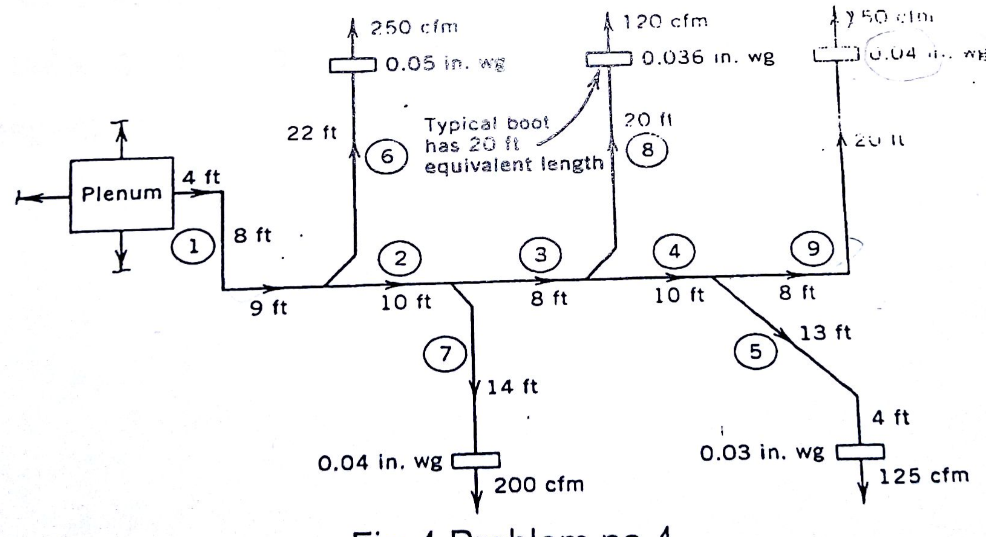
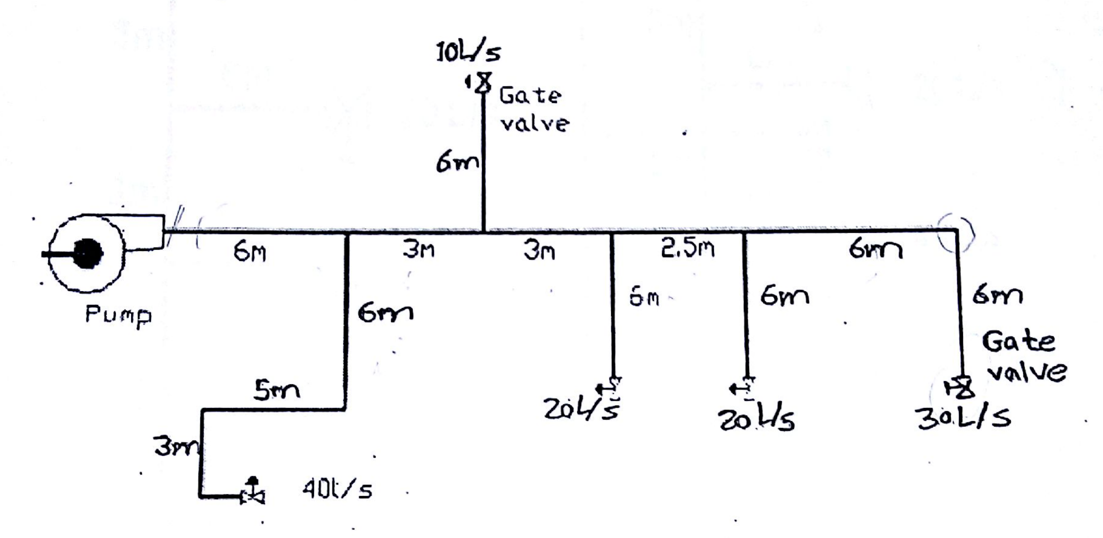


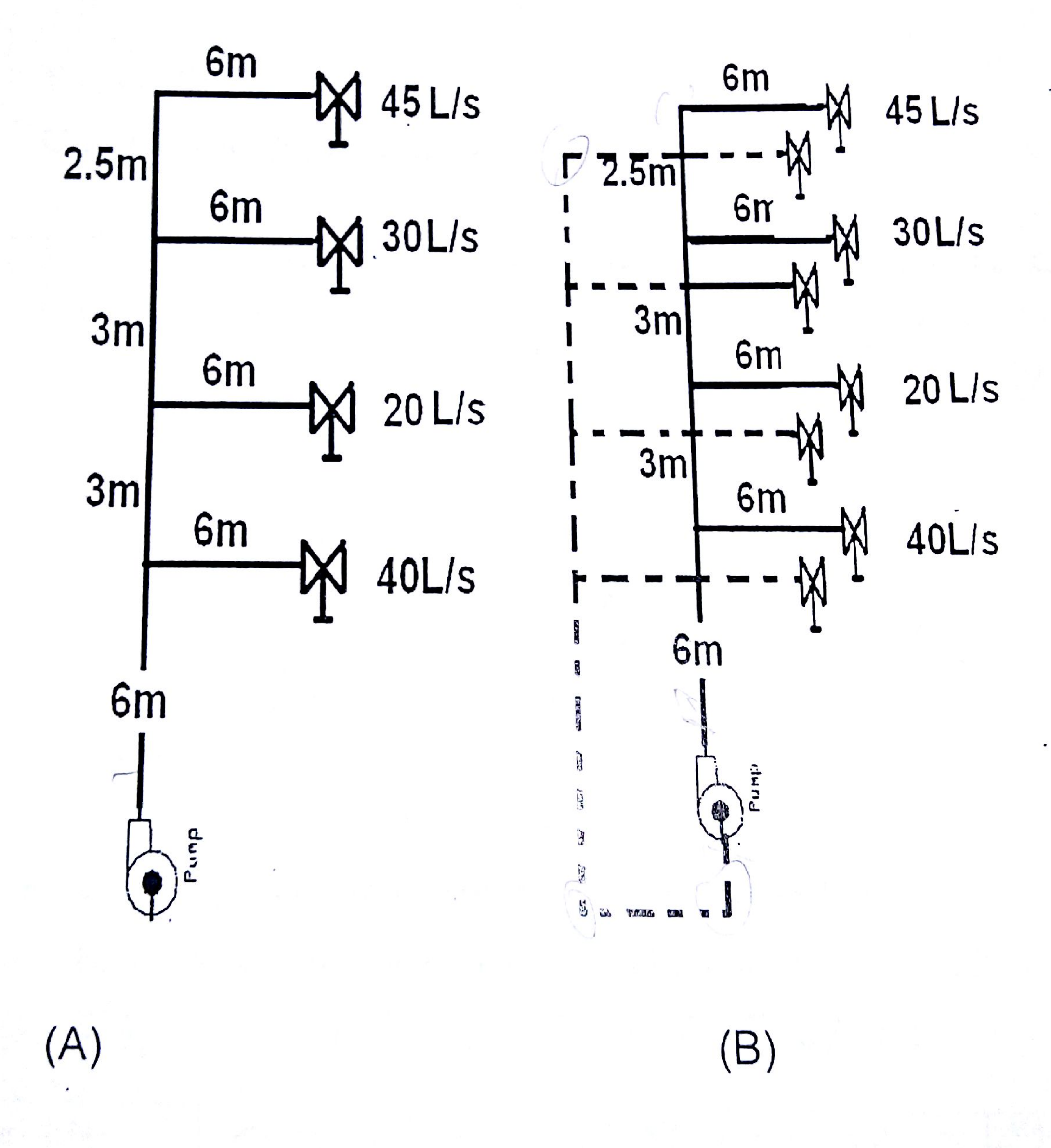
Fig-4 Problem no.4

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5. In the piping system shown schematically, size the pipes and calculate the total pressure loss (assume that, the equivalent length for each fitting losses, gate valve and check valve are is 0.6 m, 0.3 m and 6.5 m respectively.



6. In the piping system shown schematically (A) and (B), size the pipes and calculate the total pressure loss for (A) and (B). AHU coils pressure drops' from bottom to top are 200pa, 150pa, 180pa, 225 pa respectively. (assume that, the equivalent length for each fitting losses, gate valve and check valve are is 0.6 m, 0.3 m and 6.5 m respectively


6m
45 L/s
2.5m
6m
30L/s
3m
6m
20 L/s
3m
6m
40L/s
6m
Pump
6m
45 L/s
2.5m
6m
30L/s
3m
6m
20 L/s
3m
6m
40L/s
6m
Pump

(A) (B)

Sheet (5)

Duct and Pipe sizing

[1] For the duct system shown, it is required to Compute the total pressure loss where the velocity of the air is 10 m/sec and size the duct.

③ 10 ft (3 m) — 150 Cfm = 71 L/sec

V_1 = 10 m/sec

Plenum — ① 20 ft (6 m) — ② 15 ft (4.6 m) — 5 ft (1.5 m) — 5 ft (1.5 m) — ④ 5 ft (1.5 m) — 200 Cfm = 95 L/s

5 ft (1.5 m) — ⑤ 6 ft (1.5 m) — 150 Cfm (0.071 m³/s) = 71 L/sec

* The Solution *

∴ Velocity in main duct $(V_1) = 10$ m/sec.

∴ Flow rate in main duct $(\dot{Q}_1) = \dot{Q}_3 + \dot{Q}_4 + \dot{Q}_5$

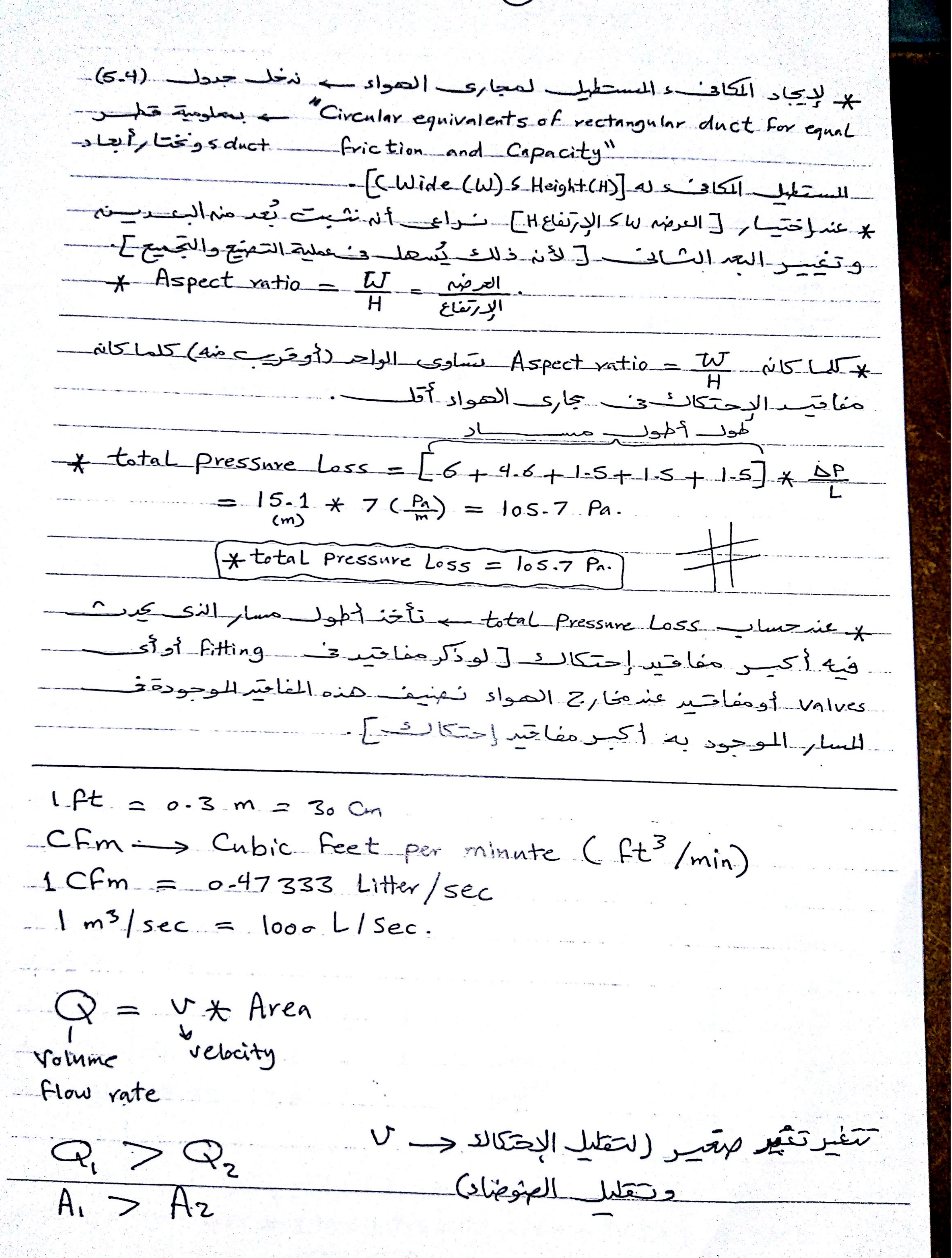
∴ $\dot{Q}_1 = 71 + 95 + 71 = 237$ L/sec.

section	Q (L/sec)	V (m/sec)	$\frac{\Delta P}{L}$ (Pa/m)	D (mm)	equivelant rectangular	
					W (mm)	H (mm)
duct ①	237	10	7	~~174~~ 200	225	150
duct ②	166	8.7	7	~~140~~ 160	150	150
duct ③	71	7.5	7	~~110~~ 125	100	150
duct ④	95	8	7	~~123~~ 125	100	150
duct ⑤	71	7.5	7	~~110~~ 125	100	150

* بمعلومية (velocity & flowrate in main duct) [V_1 & Q_1] ← ندخل خريطة Friction chart for round (Figure 5.9) ← ونوجد [D_1 & ($\frac{\Delta P}{L} = 7$)]

* Equal friction method ⟶ في هذه الطريقة يكون مقدار الفقد في الضغط لوحدة الأطوال ثابت ($\frac{\Delta P}{L}$ = cons) لمجاري الهواء المختلفة.

* في مجاري الهواء الأخرى ⟵ ندخل الخريطة بمعلومية (Flow rate Q & $\frac{\Delta P}{L}$) ونوجد كلاً من سرعة الهواء في duct وكذلك قطر duct.



* لإيجاد المكافئ المستطيل لمجاري الهواء ← ندخل جدول (5.4) "Circular equivalents of rectangular duct for equal friction and Capacity" ← بمعلومية قطر الـ duct ونختار أبعاد المستطيل المكافئ له [(Wide (W) & Height (H)].

* عند إختيار [العرض W و الإرتفاع H] نراعي أن نثبت بُعد من البعدين وتغيير البعد الثاني [لأنه ذلك يُسهل في عملية التصنيع والتجميع].

* Aspect ratio $= \frac{W}{H} = \frac{\text{العرض}}{\text{الإرتفاع}}$.

* كلما كانت Aspect ratio $= \frac{W}{H}$ تساوي الواحد (أو قريب منه) كلما كانت مفاقيد الإحتكاك في مجاري الهواء أقل.

* total pressure Loss $= \underbrace{[6 + 4.6 + 1.5 + 1.5 + 1.5]}_{\text{طول أطول مسار}} * \frac{\Delta P}{L}$

$= \underset{(m)}{15.1} * 7 \left(\frac{Pa}{m}\right) = 105.7 \; Pa.$

* total pressure Loss = 105.7 Pa.

* عند حساب total Pressure Loss ← نأخذ أطول مسار الذي يحدث فيه أكبر مفاقيد إحتكاك [لو ذكر مفاقيد في fitting أو أي valves أو مفاقيد عند مخارج الهواء نضيف هذه المفاقيد الموجودة في المسار الموجود به أكبر مفاقيد إحتكاك].

1 ft = 0.3 m = 30 Cm

CFm → Cubic feet per minute (ft^3/min)

1 CFm = 0.47333 Litter/sec

1 m^3/sec = 1000 L/Sec.

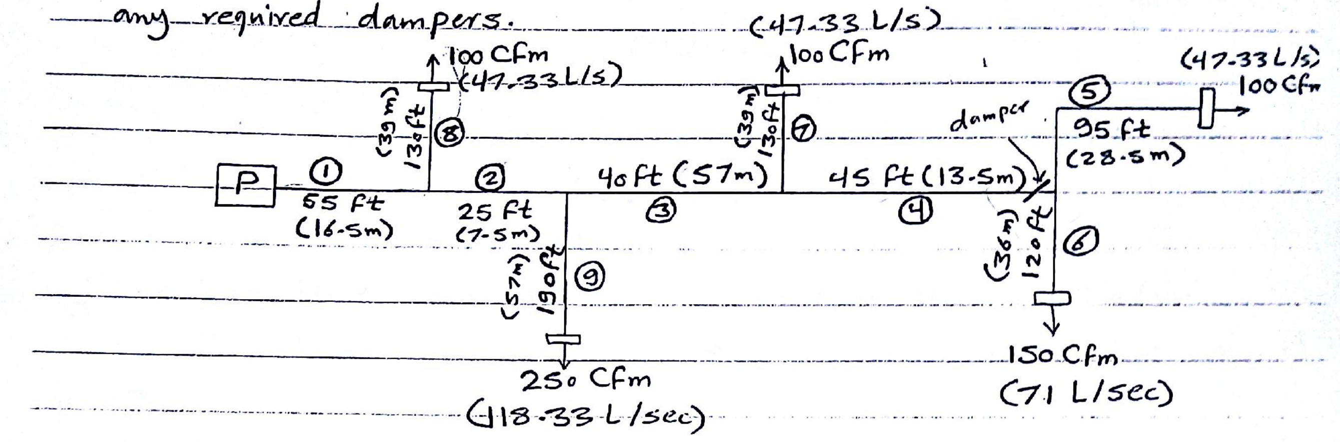
$Q = v * Area$

Q: volume flow rate; v: velocity

$Q_1 > Q_2$ — تغير تغيير صغير (لتقليل الإحتكاك → v

$A_1 > A_2$ — وتقليل الضوضاء)

② The system shown is supplied air by a roof top unit that has internal pressure losses of 500 Pa. The ducts are to be rectangular cross section and the maximum velocity in the main run is 5 m/sec. Size the supply ducts to fit his system using equal friction method. Show the location of any required dampers.



* The solution *

∴ $Q_1 = 47.33 + 47.33 + 47.33 + 118.33 + 71 = 331.33$ L/sec.

∴ flow rate in main duct = 331.33 L/sec.

∴ $V_1 = 5$ m/sec ⟶ velocity in main duct.

Section	Q (L/sec)	V (m/sec)	$\frac{\Delta P}{L}$ (Pa/m)	D (mm)	equivelant W (mm)	Rectangular H (mm)
duct ①	331.33	5	1	~~289~~ 315	450	200
duct ②	284	4.7	1	~~277~~ 315	450	200
duct ③	165.67	4.1	1	~~247~~ 250	275	200
duct ④	118.34	3.8	1	~~194~~ 200	225	150
duct ⑤	47.33	3	1	~~143~~ 160	150	150
duct ⑥	71	3.4	1	~~169~~ 200	225	150
duct ⑦	47.33	3	1	~~143~~ 160	150	150
duct ⑧	47.33	3	1	~~143~~ 160	150	150
duct ⑨	118.33	3.8	1	~~199~~ 200	225	150

* يتم وضع damper قبل أي تفريعة على شكل حرف (T) لتقسيم الهواء بين مسارين مختلفين

* Total pressure Loss = [16.5 + 7.5 + 57 + 13.5 + 36] * 1 + 500 Pa

= 630.5 Pa.

[3] Size the duct system using round steel duct.

Plenum — 20 ft (6m) [1] — 12 ft (3.6m) [2] — 8 ft (2.4m) — 8 ft (2.4m) [3] — 15 ft (4.5m) — 100 Cfm (47.33 L/s), 0.04 in. wg Pressure Loss

[4] 10 ft (3m) — 80 Cfm (37.8 L/s), 0.05 in. wg

[5] 15 ft (4.5m) — 120 Cfm (56.8 L/sec), 0.036 in. wg

* The solution *

* assume that velocity in main duct $= v_1 = 7.5\ m/sec$

↳ [Apartment or Hotel Bedrooms or Hosipital Bedrooms]

* $Q_1 = 37.8 + 56.8 + 47.33 = 142\ L/sec.$

Section	Q (L/sec)	v (m/sec)	$\frac{\Delta P}{L}$ (Pa/m)	D (mm)
duct (1)	142	7.5	5	~~145~~ 166
duct (2)	104.2	7.1	5	~~139~~ 160
duct (3)	47.33	5.8	5	100 → 100
duct (4)	37.8	5.5	5	~~91~~ 100
duct (5)	56.8	6.1	5	~~110~~ 125

* Pressure Loss in Gril (4) $= S_w \cdot g \cdot H_w = 1000 \times 9.81 \times 0.05 \times \frac{2.54}{100}$

∴ Pressure Loss in air outlet (4) = 12.45 Pa.

* Pressure Loss in (5) $= S_w \cdot g \cdot H_w = 1000 \times 9.81 * 0.036 * \frac{2.54}{100}$

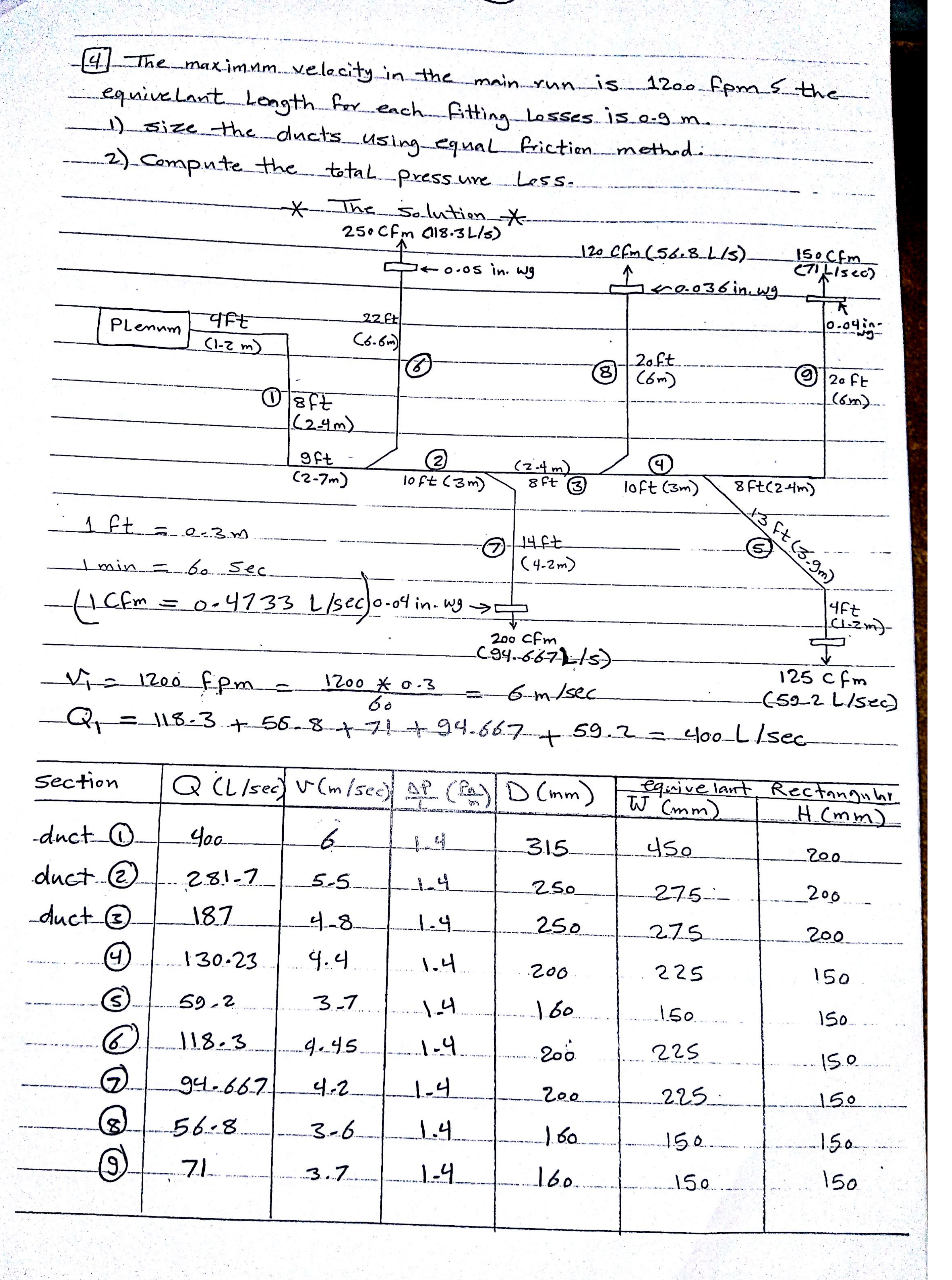
∴ Pressure Loss in air outlet (5) = 9 Pa.

* Pressure Loss in (3) $= S_w \cdot g \cdot H_w = 1000 * 9.81 * 0.04 * \frac{2.54}{100}$

∴ Pressure Loss in air outlet (3) = 10 Pa.

∴ Total Pressure Loss $= [6 + 3.6 + 2.4 + 2.4 + 4.5] * 5 + 10$

∴ Total Pressure Loss = 104.5 Pa.



4. The maximum velocity in the main run is 1200 fpm & the equivelant length for each fitting losses is 0.9 m.

1) Size the ducts using equal friction method.

2) Compute the total pressure loss.

* The solution *

1 ft = 0.3 m

1 min = 60 sec

(1 Cfm = 0.4733 L/sec)

$V_1 = 1200 \text{ fpm} = \frac{1200 * 0.3}{60} = 6 \text{ m/sec}$

$Q_1 = 118.3 + 56.8 + 71 + 94.667 + 59.2 = 400 \text{ L/sec}$

Section	Q (L/sec)	V (m/sec)	$\frac{\Delta P}{L}$ (Pa/m)	D (mm)	equivelant Rectangular W (mm)	H (mm)
duct 1	400	6	1.4	315	450	200
duct 2	281.7	5.5	1.4	250	275	200
duct 3	187	4.8	1.4	250	275	200
4	130.23	4.4	1.4	200	225	150
5	59.2	3.7	1.4	160	150	150
6	118.3	4.45	1.4	200	225	150
7	94.667	4.2	1.4	200	225	150
8	56.8	3.6	1.4	160	150	150
9	71	3.7	1.4	160	150	150

Pressure Loss in air outlet (9) $= \rho_w \cdot g \cdot H_w = 1000 \times 9.81 \times 0.04 \times \frac{2.54}{100}$

$= 10$ Pa.

∴ Total Pressure Loss $= [1.2 + 2.4 + 2.7 + 3 + 2.4 + 3 + 2.4 + 6 + 0.9 + 0.9 + 0.9] * \frac{\Delta P}{L}$ + Pressure Loss in outlet (9)

$= (25.8 \times 1.4) + 10 = 46.12$ Pa.

(5) In the piping system shown, size the pipes and calculate the total pressure loss (assume that, the equivelant length for each fitting Loss, gate valve and check valve are 0.6 m, 0.3 m and 6.5 m respectively.

Gate valve
Check valve
Pump
Gate valve
10 L/sec
(9) 6m
(1) 6m
(2) 3m
(3) 3m
(4) 2.5 m
(5) 6m
6m
6m
6m
6m
(8)
(7)
(6)
5m
3m
40 L/sec
20 L/sec
20 L/sec
Gate valve
30 L/sec

$Q_1 = 40 + 20 + 20 + 30 + 10 = 120$ L/sec.

* assume velocity in main pipe $(v_1) = 3.5$ m/sec.

* Check valve → Non Return valve (يوضع بعد المضخة)

* Gate valve → (يوضع في نهاية كل خط + قبل وبعد المضخة)

Section	Q (L/sec)	v (m/sec)	$\frac{\Delta P}{L}$ (Pa/m)	D (mm)
pipe (1)	120	3.5	460	200
pipe (2)	80	3.3	460	180
pipe (3)	70	3.25	460	170
pipe (4)	50	3	460	155
pipe (5)	30	2.5	460	125
pipe (6)	20	2.4	460	105
pipe (7)	20	2.4	460	105
pipe (8)	40	2.7	460	133
pipe (9)	10	1.9	460	85

* Total pressure drop = [6 + 3 + 3 + 2.5 + 6 + 6 + (طول أطول مسار) 0.3 (Gate valve) + 6.5 (Check valve) + 0.6 (fitting) + 0.3 (Gate valve)] * $\frac{\Delta P}{L}$ (460) = 15 732 Pa

(6)

6m — 45 L/sec — ΔP_{coils} = 225 Pa

2.5m

6m — 30 L/sec — ΔP_{coils} = 180 Pa

3m

6m — 20 L/sec — ΔP_{coils} = 150 Pa

3m

6m — 40 L/sec — ΔP_{coils} = 200 Pa

6m

Gate valve + Check valve

Pump (A)

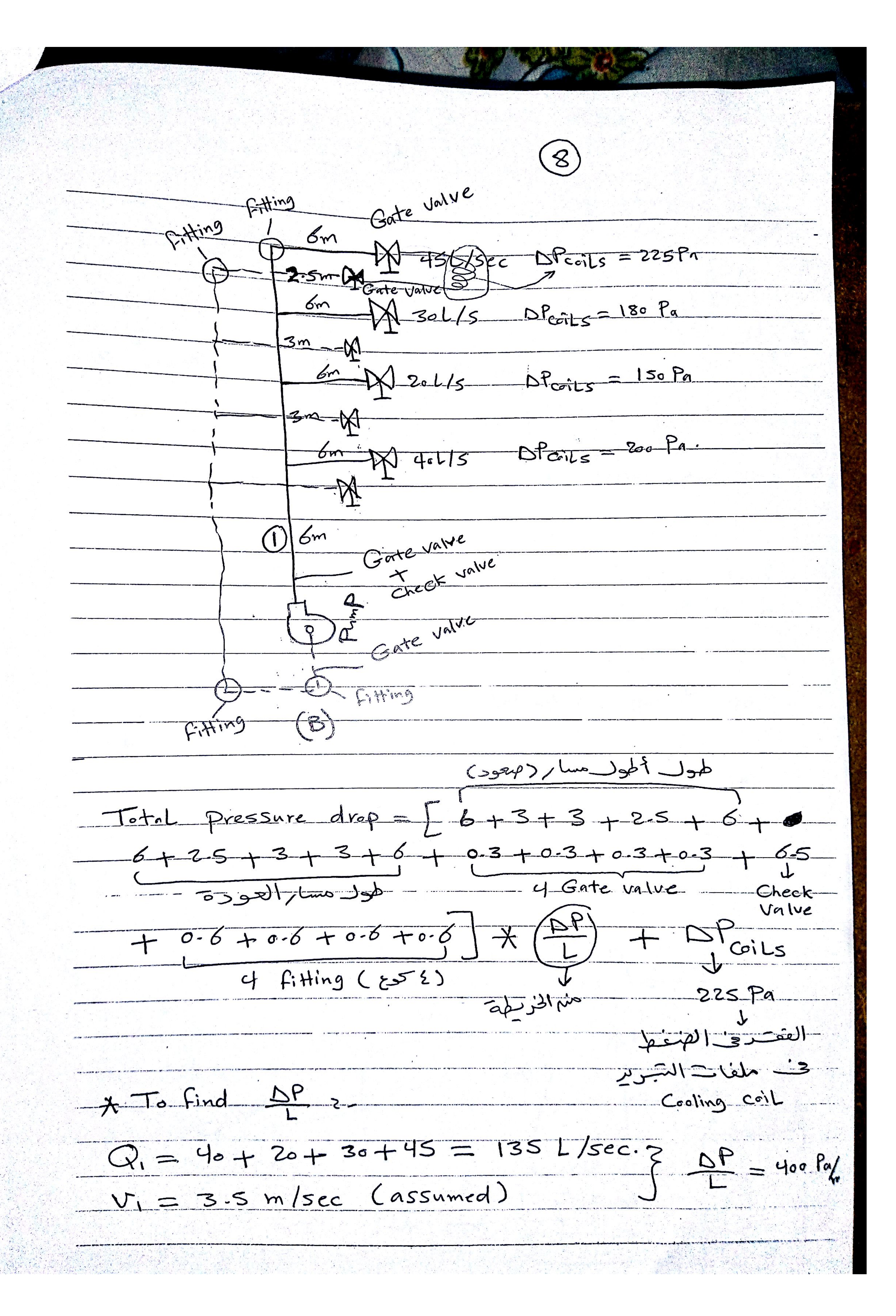
equivelant length for fitting, gate valve and Check valve are 0.6m, 0.3 m, 6.5 m respectively.

* find Total pressure Loss.

Total pressure Loss = $\rho_w \cdot g \cdot H$ (Static Pressure) + [6 + 3 + 3 + 2.5 + 6 (أطول مسار) + 0.3 (G.V) + 0.3 (G.V) + 6.5 (C.V) + 0.6 (fitting)] * $\frac{\Delta P}{L}$ (من الخريطة) + ΔP_{coil} (225 Pa)

H → الإرتفاع الرأسي من Pump حتى أعلى نقطة

H = (6 + 3 + 3 + 2.5)
= 14.5 m



طول أطول مسار (صعود)

Total pressure drop = [6 + 3 + 3 + 2.5 + 6 +

6 + 2.5 + 3 + 3 + 6 + 0.3 + 0.3 + 0.3 + 0.3 + 6.5

(طول مسار العودة) (4 Gate valve) (Check Valve)

+ 0.6 + 0.6 + 0.6 + 0.6] * $\frac{\Delta P}{L}$ + ΔP_{coils}

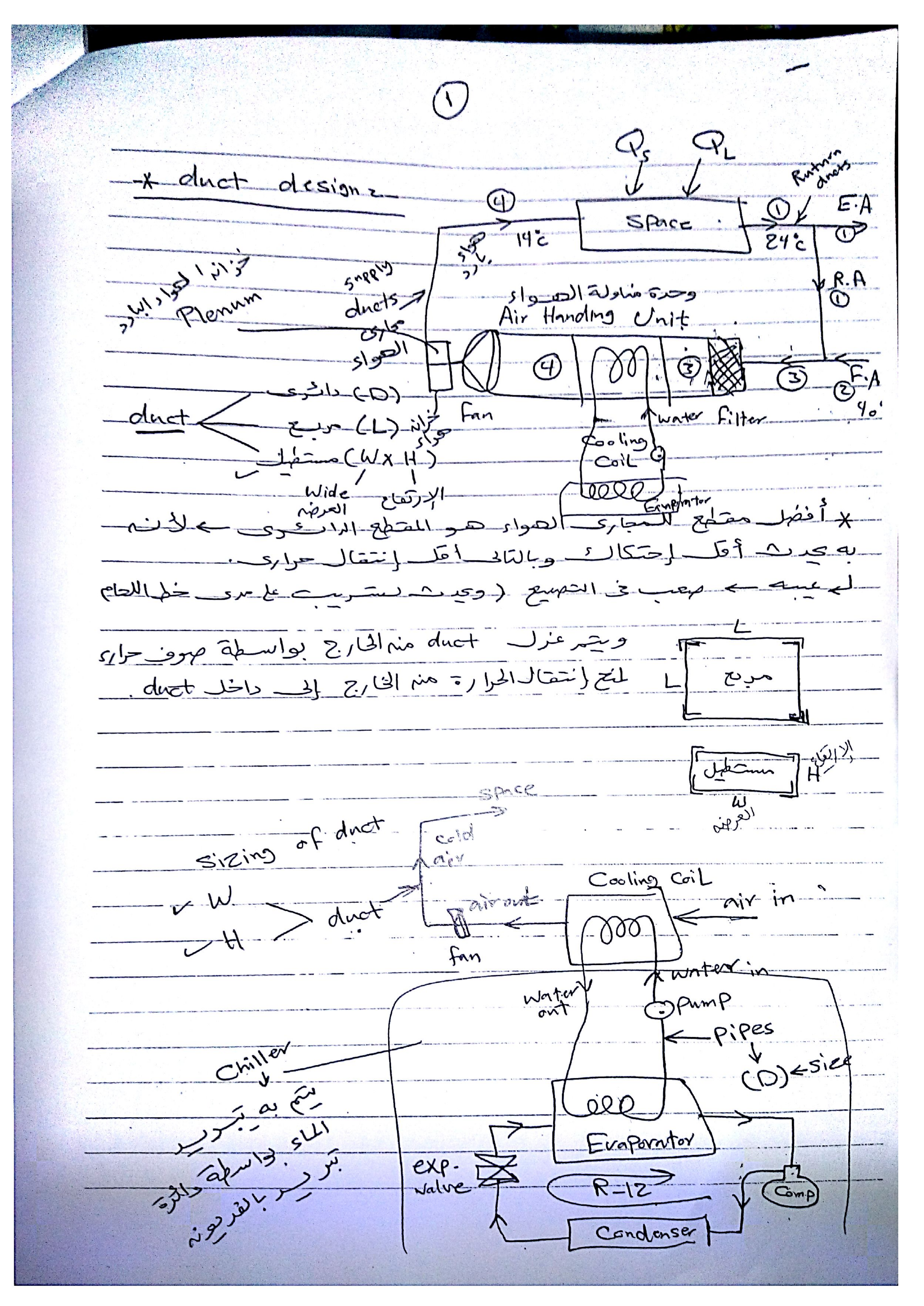
(4 fitting (٤ كوع)) ($\frac{\Delta P}{L}$ → من الخريطة) (ΔP_{coils} → 225 Pa → الفقد في الضغط في ملفات التبريد Cooling coil)

* To find $\frac{\Delta P}{L}$:-

$Q_1 = 40 + 20 + 30 + 45 = 135$ L/sec.

$V_1 = 3.5$ m/sec (assumed)

} $\frac{\Delta P}{L} = 400$ Pa/m



①

* duct design :-

duct <
- دائرى (D)
- مربع (L)
- مستطيل (W x H) — W: Wide العرض، H: الإرتفاع

* أفضل مقطع للمجارى الهواء هو المقطع الدائرى ← لأنه به يحدث أقل إحتكاك وبالتالى أقل إنتقال حرارى.

لم عيبه ← صعب فى التصنيع (ويحدث تسريب على مدى خط اللحام

ويتم عزل duct من الخارج بواسطة صوف حرارى لمنع إنتقال الحرارة من الخارج إلى داخل duct.

sizing of duct

W, H > duct

Chiller ← يتم به تبريد الماء بواسطة دائرة تبريد بالفريون